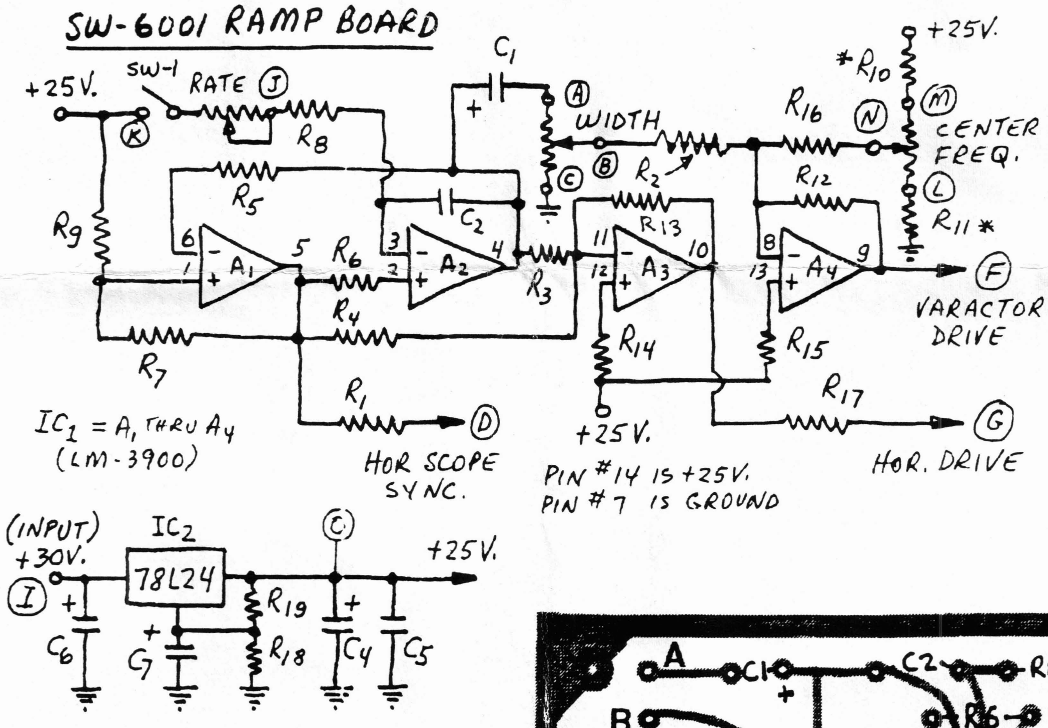


RAMP BOARD PARTS LIST

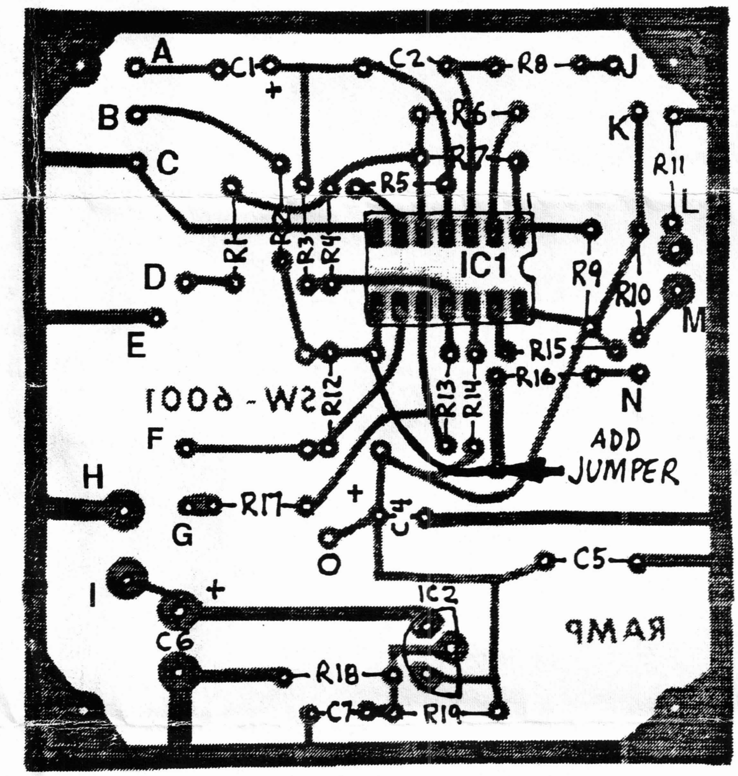
RESISTORS (May vary +-20%)

R1	10K	R2	68K
R3	330K	R4	330K
R5	33K	R6	10K
R7	47K	R8	47K
R9	1.8Meg.	R10	68K*
R11	6.8K*	R12	330K
R13	330K	R14	470K
R15	330K	R16	100K
R17	10K	R18	470 Ω
R19	13K		

IC1=LM3900 IC2=78L24

CAPACITORS

C1	10Mfd./16V TANTALUM (OBSERVE POLARITY)		
C2	0.22Mfd.		
C3	(Not used)	C6	470Mfd./35V
C4	100Mfd./35V	C7	68Mfd./10V
C5	0.22Mfd.		



Note: IC1 is either an LM3900 or a 221-235.

COMPONENT LAYOUT

CONTROLS Width=100k, Center Freq.=100k, Rate=1Meg.

SW-6010 SWITCHED FILTER KIT

This kit provides the user with the abiility to choose any one of 3 IF bandwidth resolution filters using a front panel mounted switch. Before starting to a assemble the Switched Filter Kit, we must remove 2 components from the Main Board which will be installed on to the Switched Filter PC board.

1.) ( ) Carefully remove the two 250KHZ ceramic filters FL1 and FL2 from the Main Board.

ASSEMBLING THE SW-6010 ADD-ON KIT

2.) ( ) Install 14 resistors as indicated in Fig. 1. (Resistors R12 and R13 on either side of xtal X1 are not to be installed in this version of the kit) .

3.) ( ) Install the 6 diodes as indicated. Warning! Observe polarity! The black band on the glass diode marks the cathode end.

4.) ( ) Install the 7 - 0.01 mfd disc capacitors as indicated.

5.) ( ) Install the 2 ceramic filters FL1 and FL2 (previously removed from the Main Board) in locations FL1 and FL2. These are the 250KHz filters marked with a color dot. They are symmetrical and can be installed either way.

6.) ( ) Install the 3rd 250KHz ceramic filter (supplied as part of this add-on kit) in location FL3.

7.) ( ) Install the two 55KHz ceramic filters in locations FL4 and FL5 as indicated. These are the ones without the color dot.

8.) ( ) Install the 2 IF transformers in locations L1 and L2.

9.) ( ) Install the 15KHz crystal filter at X1. Since it is symmetrical, it can be installed either way.

10.) ( ) Install the 2N3904 transistor at location Q1. The leads are pre-formed to fit the hole pattern.

This completes the assembly of the add-on board. Check all your soldered connections. Since this is a pretty "busy" little board, be sure that there aren't any cold soldered joints or solder "bridges".

The 3 IF bandpass filters and their diode switching circuits have been assembled on the SW-6010 PC board. This circuitry now has to be installed between the output of the SO-42P chip and the input of the CA3089 chip. Because of the relatively high frequency and sensitivity of this part of the circuit, we want to keep the connecting signal co-ax leads as short as possible. The add-on board will be mounted to the Main Board directly above the area where the two ceramic filters were.

11) ( ) Cut the RG-174 co-ax lead in half. Strip and tin one end of each piece of co-ax (center lead and outer shield) and connect one of them to the "IN" and the other to the "OUT" points on the PC board.

12) ( ) Estimate the length of the leads to be connected between the slide switch and the add-on board (add an inch or two) and connect one end of each lead to the appropriate points on the add-on board. The B+ and co-ax leads will go to the Main Board and should be kept as short as possible.

13.) ( ) Drill a mounting hole in a clear area of the Main Board and mount the SW-6010 add-on board to the Main Board using a spacer and appropriate hardware (or any other mounting scheme you might prefer. Just keep the shielded leads as short as possible).

14.) ( ) Estimate the length required to connect the "IN" and "OUT" shielded leads to the Main Board, then cut, strip and tin them.

15.) ( ) Connect the "IN" lead to the secondary of L3 on the Main Board. The outer shield connects to ground. See Fig.2. The inner conductor connects to the point marked "X".

16.) ( ) Connect the outer shield of the "OUT" lead to the shield of the "IN" lead (Fig.2). The inner conductor connects to the point marked "Y".

17.) ( ) Connect the B+ lead from the add-on board to the B+ terminal on the Main Board.

18.) ( ) Mount the 3-position slide switch on your front panel.

19.) ( ) Connect the 3 leads "A", "B" and "C" from the add-on board to the switch as illustrated in Fig.3.

20.) ( ) Install the R/C decoupling filter (100 ohm resistor and 10mfd/16v. capacitor) near the switch and connect it as illustrated. The junction of the resistor and capacitor goes to the switch, the other end of the resistor connects to +12 volts. Note the B+ jumper across two of the switch contacts.

This completes the installation of the SW-6010 Switched Filter add-on. The 2 IF transformers on either side of the xtal filter are pre-aligned. Should they require re-alignment, proceed as follows:

With the switch set to the 15 khz resolution position, feed an unmodulated RF signal (anywhere in the range of the analyzer) into the input of the analyzer. Center it up on your CRT display, reduce the width of the display so that you can see about a 1/8" space between the skirts of the "pip", and adjust L1 and L2 on the add-on board for maximum amplitude and symmetry. If a signal generator is not available, find a "pip" anywhere on your CRT display that represents an unmodulated carrier (one that isn't wiggling and/or changing in amplitude) and use it for the touch up adjustment.

NOTE: As the IF bandpass is narrowed (especially in the case of the 15 khz xtal filter position) the sweep rate becomes important. Since the filters have a time constant, they have to charge and discharge as the spectrum is swept. If they are swept too quickly, they do not have enough time to charge and discharge. This shows up as a widening of the "pip", which defeats the primary advantage of the narrow band filters. In addition, if the filters do not have enough time to charge, many signals may not have enough energy to produce any visible display, creating the impression that the sensitivity of the analyzer has been greatly reduced. Increasing sweep WIDTH has the same effect as increasing the sweep RATE, since we are scanning a greater segment of the spectrum in each sweep. Since we are covering a greater "distance" in the same amount of time, we must be sweeping through these frequencies at a greater rate of speed. This makes the 250 khz position look much better than the 15 khz position in many cases. When you see this effect, find a segment of the spectrum where there are few very closely spaced signals. Reduce the width to expand that part of the spectrum, then reduce the sweep rate so that the flicker becomes quite obvious and switch between the 250 khz and 15 khz positions to see the difference in resolution. Many spectrum analyzer displays use long persistence phosphors in the CRT to minimize flicker when the scan rates are reduced to accommodate the narrow band filters.

PC BOARD PARTS LIST			
Resistors		**Capacitors**	**Ceramic Filters**
R1 - 220 ohm	R9 - 2.2K	C1 thru C7 - .01mfd	FL1 thru FL3 - 250 KHz
R2 - 2.2K	R10 - 20K		FL4 & FL5 - 55 KHz
R3 - 4.7K	R11 - 2.2K	**Diodes**	
R4 - 4.7K	R12 - not used	D1 thru D6 - 1N4148	**Transistors**
R5 - 100K	R13 - not used		Q1 - 2N3904
R6 - 4.7K	R14 - 4.7K	**IF Transformers**	
R7 - 100K	R15 - 470 ohm	L1 & L2 - 10.7 MHz	**Crystal Filter**
R8 - 4.7K	R16 - 100K		X1 - 10.7 MHz

The 100 ohm resistor & the 100mfd capacitor are not installed on the PC board.

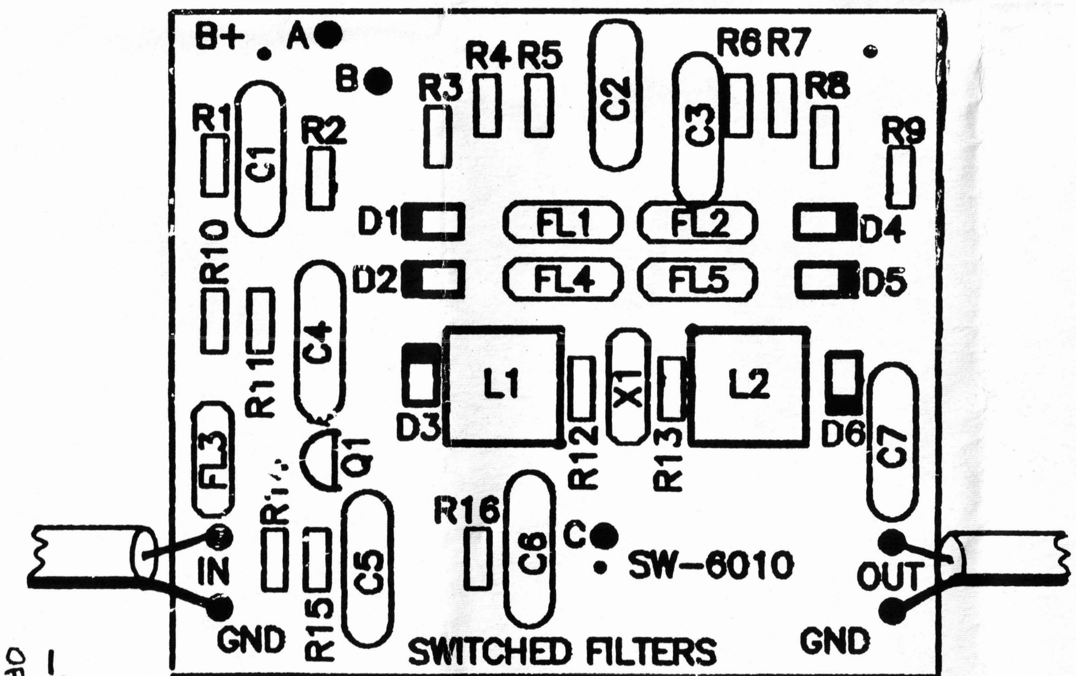


Fig.1

FILTER AREA OF MAIN BOARD

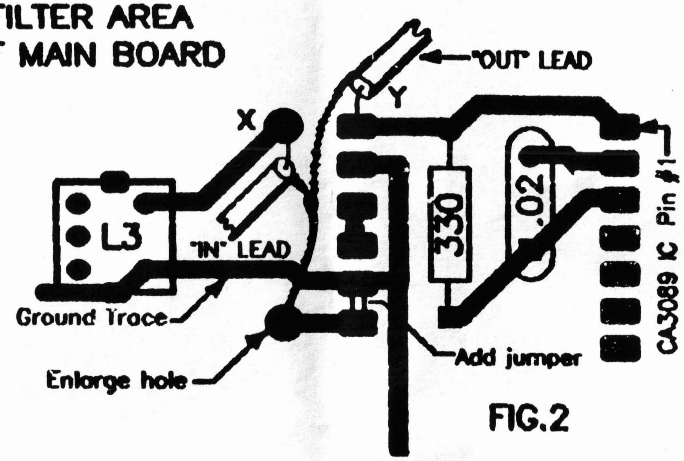


FIG.2

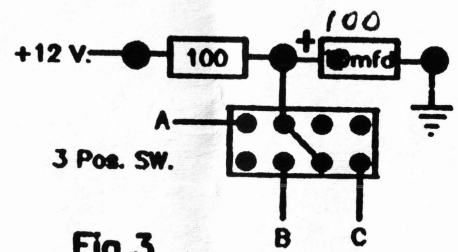
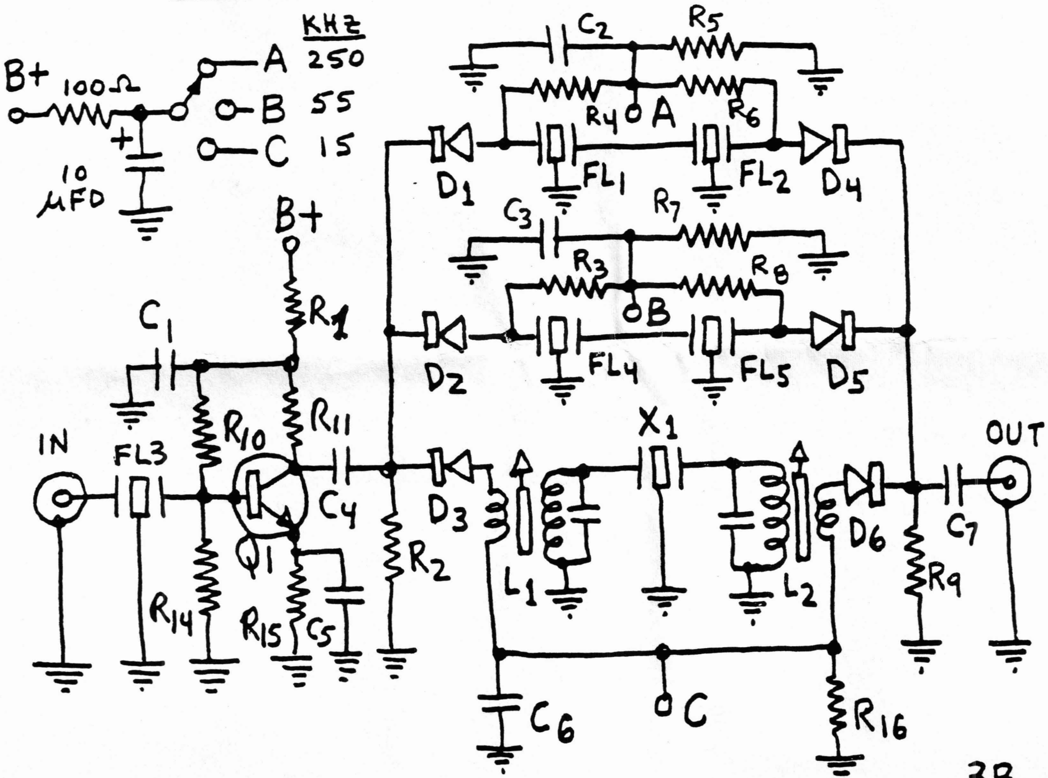


Fig.3

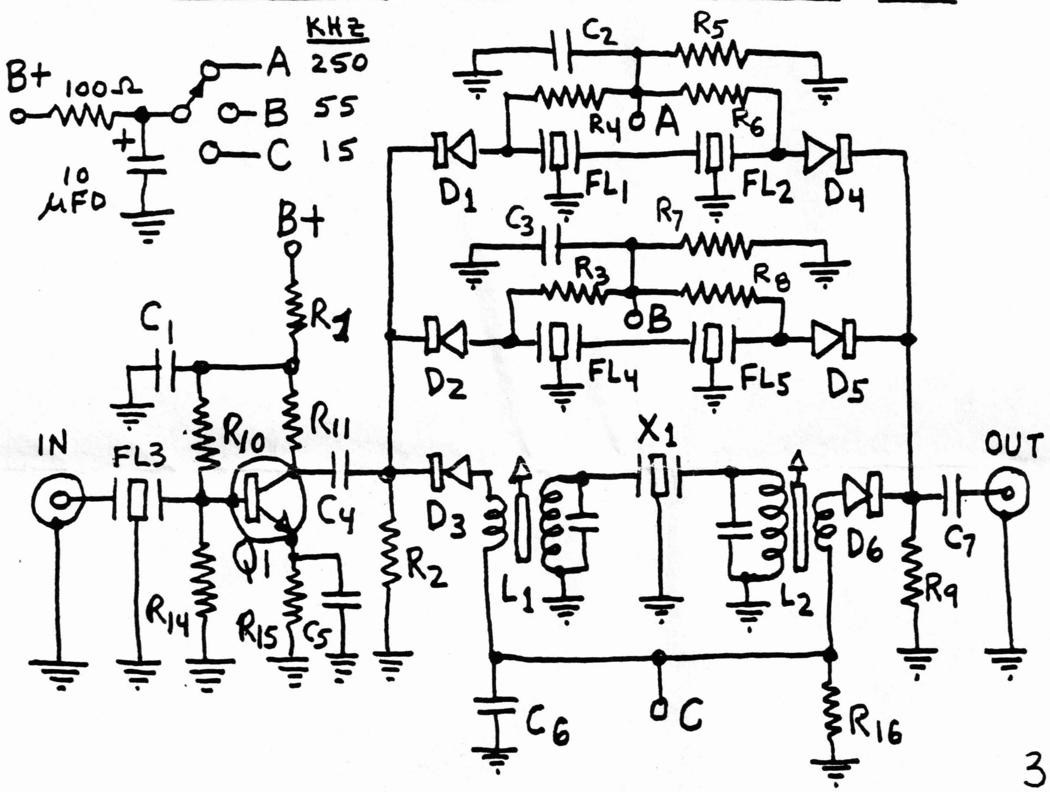
Rev. 1

SW-6010 SWITCHED FILTER KIT



3B

SW-6010 SWITCHED FILTER KIT


3B

SW-PS1 SPECTRUM ANALYZER POWER SUPPLY

The SW-PS1 Power Supply Kit contains the printed circuit board and components (other than the power transformer) that are required for most functions of the Spectrum Analyzer. I've added the word "most" because the choice of features determines the power supply requirements. For example: If you didn't chose to add the LED display to your instrument, you wouldn't need the extra isolated 5 volt supply. It wouldn't be fair to have you pay for the extra components necessary for this 2nd 5 volt supply. So, I've provided the circuitry for it on the power supply board, but I have not included those extra components. (See discussion on LCD/LED display power.)

Secondly, since power transformers are heavy and bulky (and are available from Radio Shack, etc. at prices that I can't beat), I've chosen not to add them to this kit.

POWER REQUIREMENTS

The following table lists the voltage and approximate current requirements for the various modules presently available for the Poor Man's Spectrum Analyzer.

Module	Voltage	Current
Main Board (SW-6006)	12	40 ma.
Ramp Board (SW-6001)	33	25 ma.
VHF Tuner (SW-5800)		
B+	24	100 ma.
prescaler	5	75 ma.
UHF Tuner (SW-5810)	18	30 ma.
DRO Board (SW-6007)	18	20 ma.
	5	30 ma.
LCD Display	5*	10 ma.
LED Display	5*	80 ma.

* Isolated supply.

Although the Main Board and the Tuners B+ supplies really do not have to be regulated, the added decoupling and filtering provided by the regulators, makes their use worth while. In addition, the use of 1 ampere regulators may seem to be overkill, but the relatively small difference in cost between them and the lower current versions makes them the better choice.

ASSEMBLY NOTES

You MUST observe the polarity (and regulator pin #1) markings on all of the components, except the disc capacitors! Refer to the drawings on the PC board and in these instructions. Heat sink the voltage regulators (78XX) by mounting them on the chassis. Run leads from the PC board to their terminals, as in Fig.1 . Note the position of the #1 pin. The large, flat side of the regulator IC's should be flat against the chassis for maximum heat transfer.
The 24 volt power transformer is the Radio Shack part number 273-1366, or any other 24 volt center tapped transformer capable of delivering 450 ma.

PARTS LIST

Diodes

4 - 1N4004 (D1-D4)

PC Boards

1 - SW-PS1 PC Board

Voltage Regulators

1 - 7824 (U1) 1 - 7818 (U2) 1 - 7812 (U3) 1 - 7805 (U4)

Disc Capacitors

8 - 0.1mfd (C2,C3,C5,C6,C8,C9,C11 & C12)

Electrolytic Capacitors

1 - 1,000mfd/50V. (C1)   1 - 470mfd/35V. (C4)
1 - 2,200mfd/35V. (C7)   1 - 10mfd/16V. (C10)

LED/LCD DISPLAY ISOLATED POWER SUPPLY

If you are adding a LED or LCD center frequency display and it does not have it's own power supply, you can add the appropriate components to the lower half of the power supply board. The LED display requires approximately 80 ma., while the LCD only needs about 10 ma. We can steal the 10 ma. for the LCD display from the +18 volt supply, using the circuit supplied with the LCD display. However, the LED's higher current drain requires a separate, small power transformer. Either a 6 volt, 9 volt or 1/2 of a 12 volt center-tapped transformer will do. The other parts are: D1 - 1N4001, C13 - 470mfd/25V., C14 and C15 - 0.1mfd disc capacitor and U5 is either a 78L05 or a 7805 regulator. These parts should be available from Radio Shack, or most other parts suppliers.

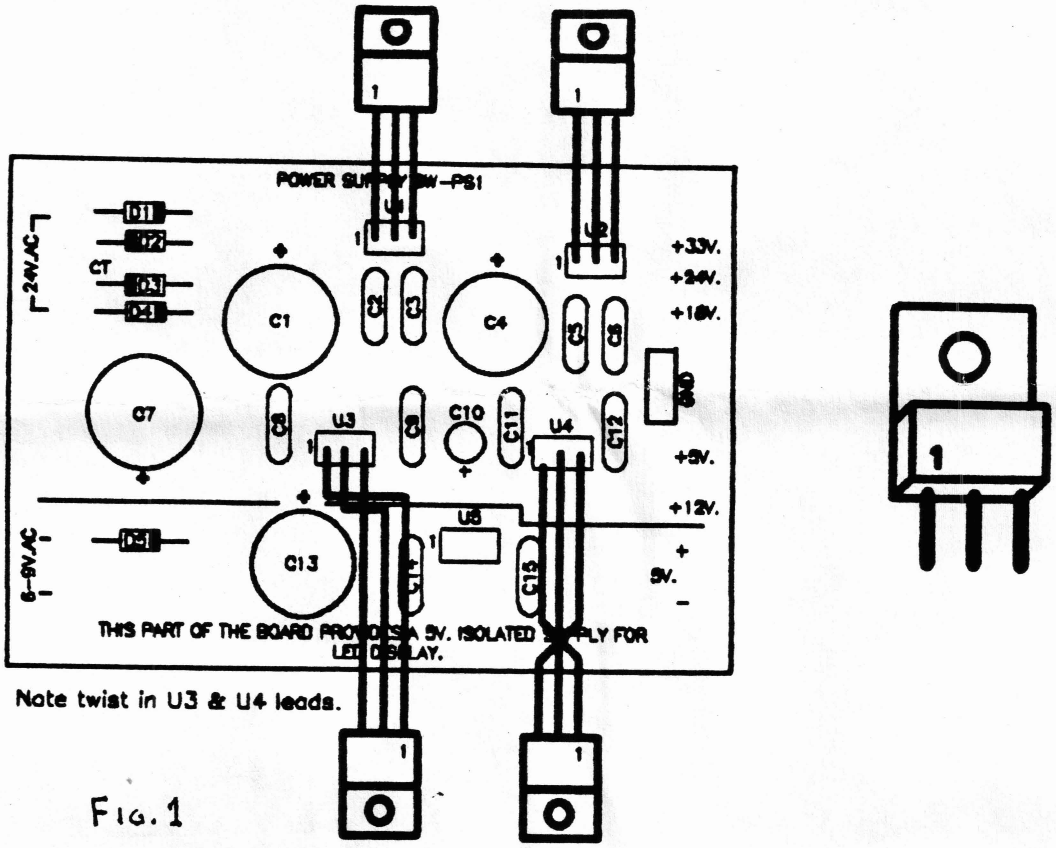

POWER SUPPLY SW-PS1
24V.AC
CT
D1
D2
D3
D4
C1
C4
C7
C10
C11
C12
C13
U1
U2
U3
U4
U5
+33V.
+24V.
+18V.
+5V.
+12V.
5V.
6-9V.AC
THIS PART OF THE BOARD PROVIDES A 5V. ISOLATED SUPPLY FOR LED DISPLAY.
Note twist in U3 & U4 leads.
1

Fig. 1

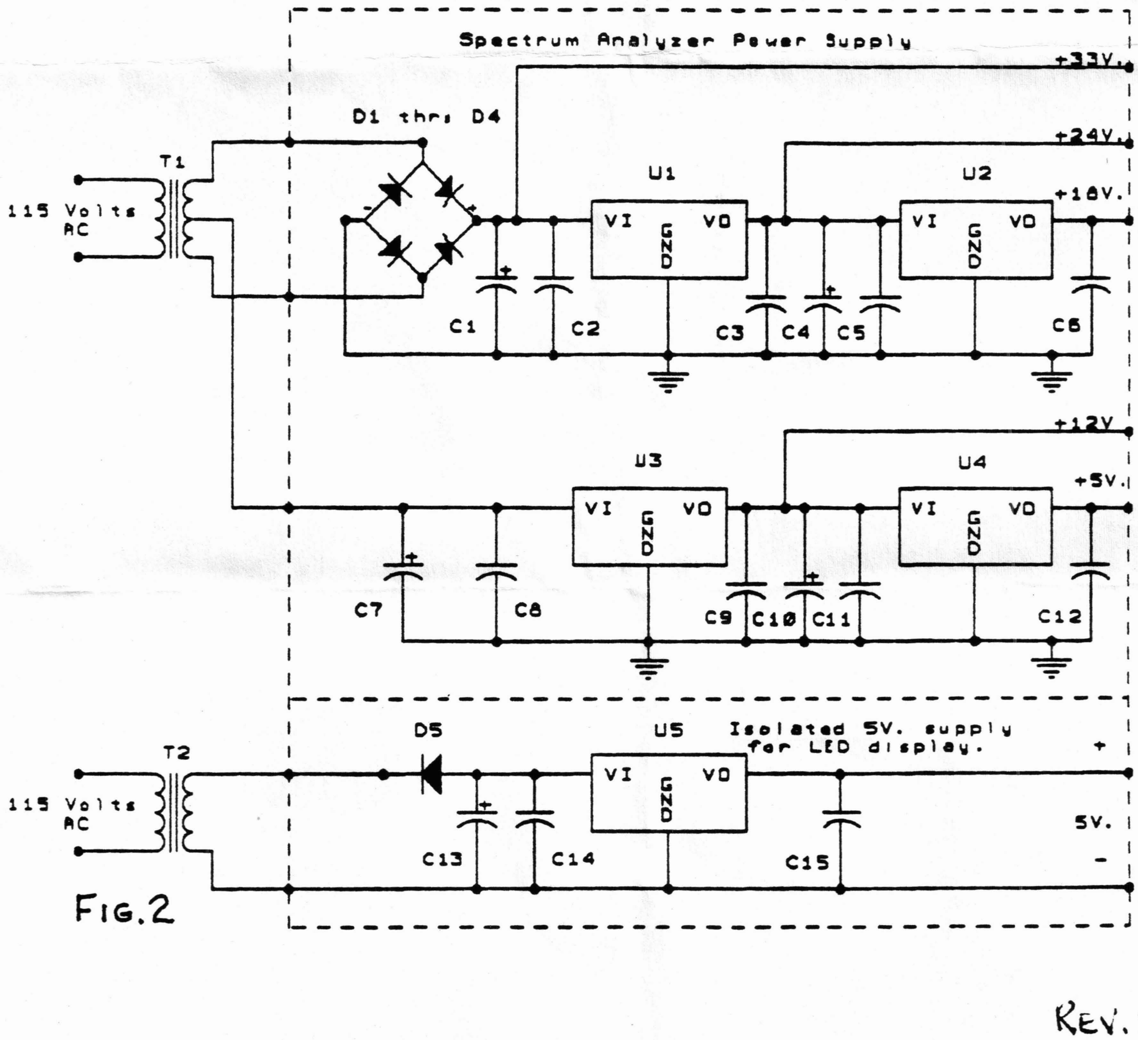

Spectrum Analyzer Power Supply
+33V.
D1 thru D4
+24V.
T1
U1
U2
+18V.
115 Volts AC
VI
VO
GND
C1
C2
C3
C4
C5
C6
+12V
U3
U4
+5V.
C7
C8
C9
C10
C11
C12
D5
U5
Isolated 5V. supply for LED display.
T2
+
5V.
-
C13
C14
C15

Fig. 2

SCIENCE WORKSHOP SW-5900 TRACKING GENERATOR

The addition of a Tracking Generator to the Spectrum Analyzer provides a powerful receiver system for stimulus-response measurements. Since the instantaneous output frequency of the SW-5900 matches the instantaneous input frequency of the Spectrum Analyzer, the swept frequency test system acts as a very sensitive synchronous detector. Harmonics of the signal are not displayed because the Tracking Generator output is always at the Spectrum Analyzer input frequency. This makes it the ideal setup for measuring the frequency response of active and passive devices such as amplifiers, filters, couplers, attenuators, transmission lines, and even antennas when used with an external bridge.

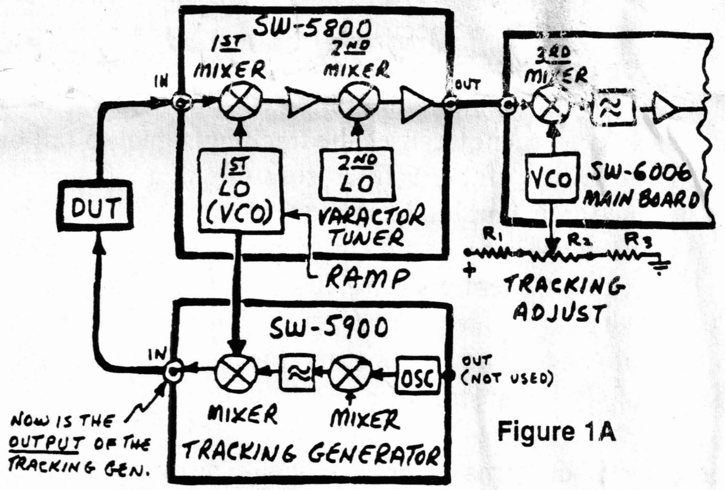


Figure 1A

The Tracking Generator output signal is generated by mixing two or more oscillators. Figures 1A and 1B are simplified block diagrams of the Science Workshop Spectrum Analyzer/Tracking Generator. The incoming signal to the Spectrum Analyzer mixes with the Local Osc., and when the mixing product equals the IF, this signal passes through to the detector. The detector output is amplified and produces a vertical deflection on the CRT display. Synchronism between the horizontal frequency axis of the CRT display and the tuning of the LO is provided by the sweep (ramp) generator, which drives the horizontal CRT deflection and tunes the LO. The Tracking Generator uses the same swept LO from the Spectrum Analyzer and mixes it with a fixed IF oscillator.

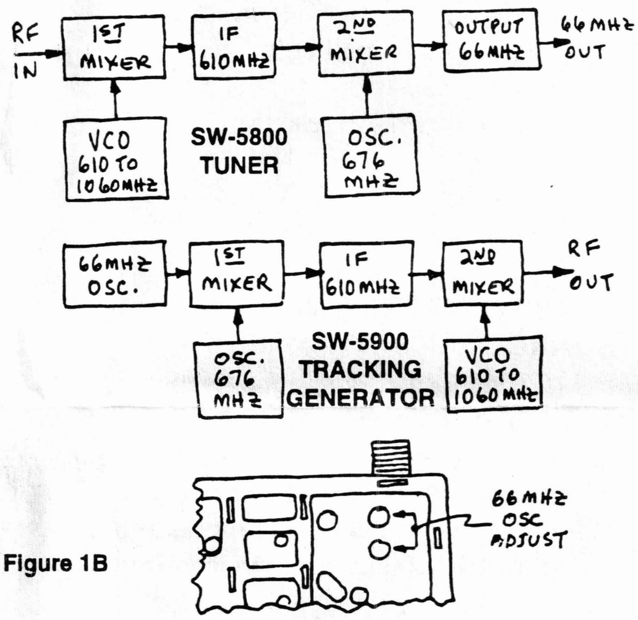
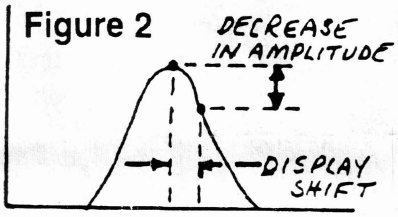


Figure 1B

Since the LO from the Spectrum Analyzer is used by the Tracking Generator to produce it's output, it is always in sync.



TRACKING GENERATOR FREQ. SHIFTED FROM CENTER OF IF BANDWIDTH.

A tracking error occurs if the Tracking Generator's output frequency is not exactly matched to the input frequency of the Spectrum Analyzer. The resulting mixing product from the Spectrum Analyzer's input mixer is not at the center of the IF bandwidth. This shift in frequency causes the tracking signal to fall on to the skirts of the IF filter, resulting in a reduction in amplitude of the display. (See Fig.2) To compensate for any tracking error that might occur, Tracking Generators provide a front panel adjustment of the IF oscillator. This tracking control is tuned to maximize the amplitude of the trace and should be adjusted before any measurements are made. Once the IF oscillator is adjusted, the spans of the two instruments are matched and synchronous, and precise tracking is assured.

Before adding the Tracking Generator module, make sure that your Spectrum Analyzer is working properly. Tune in a single, strong, reliable carrier that you can depend upon for a reference check after the Tracking Generator module is installed. A signal generator is best for this step, but a local TV station is a good reference. Once this is done, mark the settings so that you can duplicate the display.

Your Tracking Generator package consists of:

1.) SW-5900 Tracking Generator module.
2.) A package of small component parts, containing:
- 1-3.3k 1/4 W. resistor.
- 1-100k " "
- 1-0.1mfd. disc capacitor.
- 1-MV2101 varactor diode.

MODIFYING THE SW-6006 MAIN BOARD

The 4 small components must be added to the SW-6006 Main Board. Install them in the upper left hand corner, near the 'E' terminal, as shown in figure 3. Carefully remove the 3.3pf disc capacitor next to L1 and re-install as shown. Connect a lead to terminal 'E', long enough to reach a control that you will be installing on the front panel.

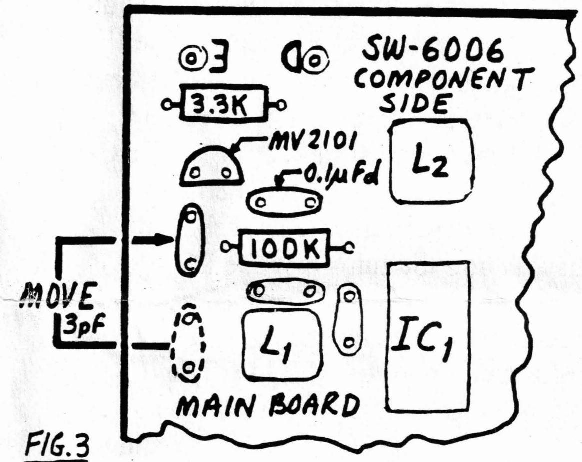
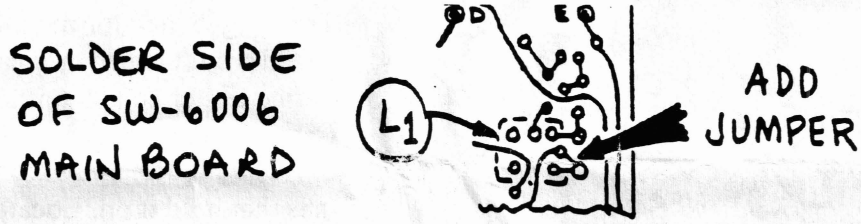


FIG.3

Looking at the solder side of the Main Board, solder a small jumper from the bottom of the L1 secondary winding to the ground pin located between the 2 secondary pins as illustrated below.



This completes the work on the Main Board.

ADDING THE "TRACKING ADJUST" CONTROL

When we moved the 3pf disc on the Main Board, we added a varactor tuning circuit to the oscillator on this board. This now allows us to tune this oscillator from the front panel. Since we only need a slight adjustment to center the signals in the passband of the 10.7 Mhz IF filters, we will set up a voltage divider to provide the voltage required to produce the desired frequency change. Temporarily connect the 'Tracking Adjust' control potentiometer (any value greater than IK) across the regulated output of the Ramp Board (terminal '0') to ground. Connect the center arm to 'E' on the Main Board (SW-6006). Turn on your Spectrum Analyzer. Carefully adjust the potentiometer so that the display duplicates the one you had previously set up as a reference. The control will tune very FAST and may stop the oscillator at either or both ends of it's rotation. This is to be expected because of the large voltage swing on the varactor diode. Carefully adjust the control for maximum amplitude of the reference carrier. When you are certain that you have maximum amplitude of the original signal, measure and record the voltage on the center arm of the control. This is the voltage we want applied when the 'Tracking Adjust' control is set to the center of it's range. We will want the control to vary +/- 1 volt from this value. To do this, we will add a pair of 'wing' resistors (R1 and R3) on each end of the control (figure 1A).

Let's use a hypothetical value of 5 volts on the center arm of the control to calculate the values of the two series resistors. Assuming a 20 Volt supply, and a 10K control (it can be any value), we want a 2 volt drop across it (1 volt on either side of the center arm). That puts the top of the control at 6 volts and the bottom at 4 volts. Therefor, we want a 4 volt drop across the bottom resistor and a 14 volt drop across the top one (all the voltage drops adding up to the 20 volt supply). If the 10K control produces a 2 volt drop, then we need 2 times that resistance to produce the 4 volt drop across R3, and 7 times the 10K resistance to produce the 14 volt drop across R1. Therefor, 7 x 10K = 70K for R1, and 2 x 10K = 20K for R3.

Use YOUR measured voltage and the value of the control you will be using to calculate your values of R1 and R3. Use the closest standard resistor values. Wire up the control circuit and measure the results before continuing.

INSTALLING THE SW-5900 TRACKING GENERATOR MODULE

The SW-5900 Tracking Generator module should be mounted alongside the SW-5800 tuner, since they must be connected together by the co-ax cable. There are only 3 connections to the Tracking Generator module, 24 V. (B+), ground and the co-ax cable. Do not use '0' on the

Ramp Board for B+, since these modules draw over 100 ma. each, which would exceed the capacity the 78L18.

Remove 1/2" of insulation from the loose end of the co-ax lead attached to the SW-5900 Tracking Generator module. Separate the shield from the center conductor. Strip and tin the center conductor and the shield. Carefully remove the top cover from the SW-5800 tuner, by straightening the twist tabs that hold it on. Locate the point labeled 'CONNECT HERE' in figure 4. Drill or punch a hole in the top cover large enough to pass the co-ax, so that the hole will be directly above this point when the cover is re-installed. Feed the end of the co-ax you have prepared, through this hole in the top cover. Carefully solder the center conductor of the co-ax to the feed thru lead labelled 'CONNECT HERE'. This point is connected to the pick-up loop in the 1st local oscillator compartment. Do not disconnect the small disc capacitor that is already connected there. Next, carefully solder the co-ax shield to the side of the thin metal shield around the pre-scaler chip. After you have checked your work carefully, re-install the top cover on the SW-5800 tuner and carefully re-bend the tabs.

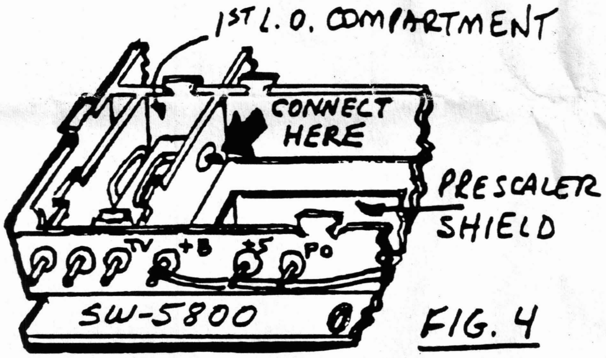


FIG. 4

TRANSMISSION MEASUREMENTS

The combination of a Spectrum Analyzer and Tracking Generator makes it possible to check insertion loss, gain and frequency response. Figure 1A illustrates the set-up. The RF output from the Tracking Generator is connected to the input of the Device Under Test (DUT), and the output of the DUT is connected to the input of the Spectrum Analyzer, A small test fixture should be built to make it convenient to insert devices to be tested between the output of the Tracking Generator and the input to the Spectrum Analyzer. Exposed test leads should be kept as short as possible to minimize stray inductance and capacitance, and unwanted RF signals. Before a measurement is made, the DUT should be removed and the output of the Tracking Generattor should be connected directly to the input of the Spectrum Analyzer. The center frequency and width controls should be set to center the display. The 'tracking adjust' control should then be adjusted for maximum upward deflection of the display, Since the tracking control centers the tracking signal in the bandpass of the filter, it can also to serve to adjust the sensitivity of the analyzer and shift the display into a more linear area, Anything other than a straight , horiztontal line (except at the high and low frequency ends of the scan) might indicate that:

a.) The width control is probably set too wide. (Use the minimum width necessary to display the frequency response curve. Since we do not have an automatic leveling circuit, which would add substantially to the cost, the output of the tracking generator is not necessarily constant over the full range of frequencies).

b.) There may be standing waves on the leads connecting the two units. Try terminating them with a 75 ohm resistor.

MAKING YOUR FIRST MEASUREMENT

After you have assembled and checked out everything, you will want to see if the combination Spectrum Analyzer/Monitor Receiver/Tracking Generator really works! The easiest way I've found is to hang a piece of co-ax, approximately 10 to 12 inches long in parallel with the input and output of the two modules, in place of the DUT. Tune across the spectrum for a notch in the response curve, If you remember your transmission line theory, you may recall that an open 1/4 wave line reflects a short circuit back to the beginning of the line, acting as a trap at that frequency, which accounts for the notch. Now, start clipping 1/4' lengths from the open end of the co-ax and watch the notch move up in frequency! Now, if we had a counter that would read out the center frequency ...(like the Digital Readout Board)....we could see what that frequency is. If we go back to the 1/4 wave length co-ax and try terminating it with different values of resistance until the notch disappears, it ought to tell us what the characteristic impedance of that co-ax material is at that frequency! Can you imagine the possibilities? Connect the transmission line from your antenna in place of the 1/4 wave stub we've been looking at. You may be in for a surprise!

I've only hinted at the possibilities. If youv'e had enough smarts to order my "Poor Man's Tracking Generator", then I'm sure you have the smarts to find a lot more applications than I've mentioned! I would like to hear about them.

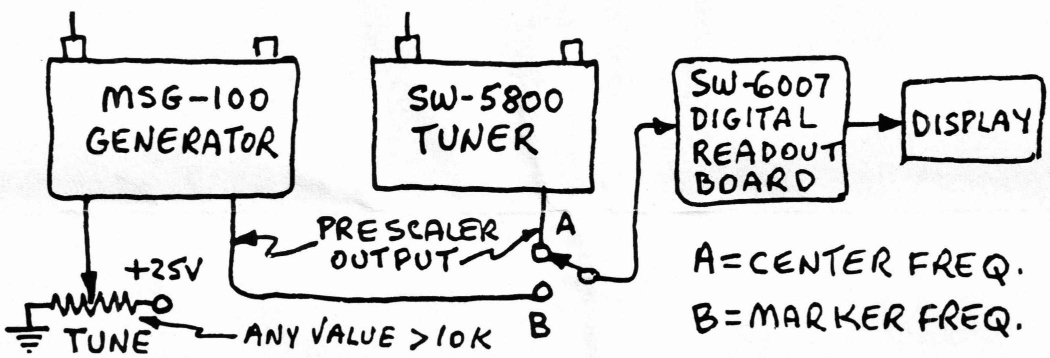
SCIENCE WORKSHOP MARKER/SIGNAL GENERATOR, MSG-100

The Science Workshop MSG-100 Marker/Signal Generator is another illustration of our stated goal to provide the experimenter with extremely low-cost, useful electronic equipment. As with the "Poor Man's Spectrum Analyzer", it allows us to substitute a little "smarts" for a "lotta-bucks"! And once again, the key word is COMPROMISE! The compromises here are the same as those for the "Poor Man's Spectrum Analyzer":

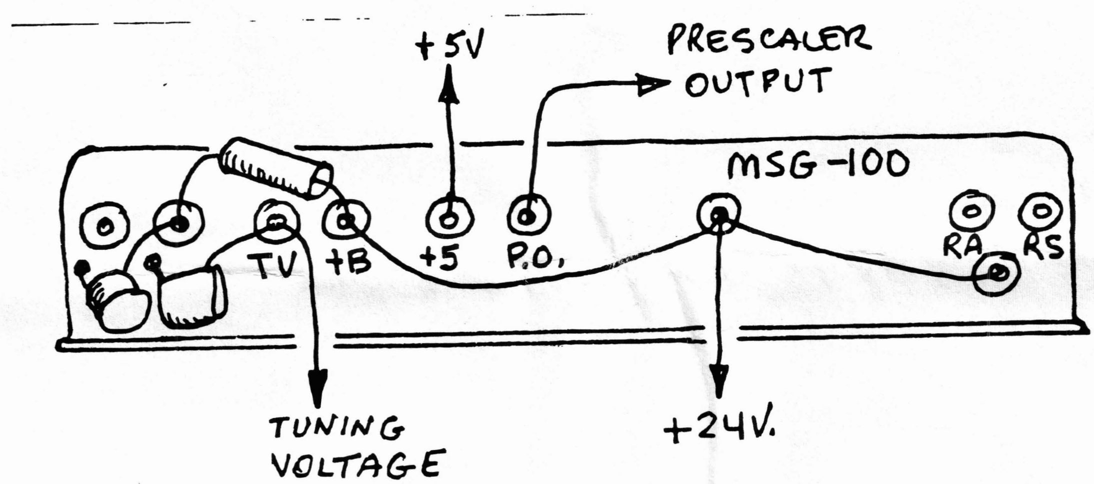
No Power Supply. No Calibration or Specifications. No "easy-to-get" parts or hardware that would be required to complete the project are supplied. No claim that it replaces Tektronix or Hewlett Packard equipment. However, as with the "Poor Man's Spectrum Analyzer", what we do supply and guarantee, is a great educational experience, a small dose of frustration as you try to decipher my best efforts to describe how to assemble, test and apply the results of your labors, and a lot of "bang" for the "buck"!

The MSG-100 Generator is a voltage-tuned signal generator module designed to produce a frequency marker "pip" when used in conjunction with the "Poor Man's Spectrum Analyzer". It's frequency range is approximately 5 to 450 MHz with an output of approximately 10 millivolts into 75 ohms. Even though the SW-6007 Digital Readout Kit identifies the center of the analyzer's display, the addition of the Marker Generator makes it easy to quickly identify each individual signal. It can also be built into it's own enclosure, with it's own Digital Frequency Readout and used as a "stand-alone" signal generator in a variety of other everyday applications. Additional circuitry can be added (such as attenuators, amplifiers and modulators) to make it more useful as a "stand-alone" generator.

The MSG-100 module is actually another modified cable tuner, modified this time to provide a single signal, rather than the swept signal produced by the SW-5900 Tracking Generator module. The principle of operation here is the same as the Tracking Generator, except that this module has it's own VFO, rather than using the VFO from the SW-5800 tuner. This gives us the ability to (voltage) tune it independently over the same frequency range as the SW-5800 modules. Since the MSG-100 also has an internal pre-scaler, we can use the SW-6007 Digital Frequency Readout Kit to display it's frequency, just as we use it to display the SW-5800 tuner's center frequency. This is accomplished by simply adding a SPDT switch, as illustrated.



Installation should not present any problem. Physically, the module can be mounted in the same box as the Spectrum Analyzer, since it is a well shielded module, or it can be assembled into it's own box with it's own power supply and additional, optional circuitry.



Power requirements are the same as for the SW-5800 tuner, 24 volts @ 100 ma. and 5 volts @ 80 ma. (for the pre-scaler), plus a well filtered, well regulated 25 volts for the tuning voltage, such as that provided by the regulator on the SW-6001 Ramp Board.

ADDITIONAL CIRCUITRY

You might want to consider some of the following suggestions to make the module more useful for "stand-alone" applications:

1.) Add (build or buy) a wide band amplifier to boost the output level.

Radio Shack sells a 5 to 900 MHz 10 dB coaxial 75-ohm inline amplifier (Cat. No, 15-1117) for $14.95, complete with a wall plug power supply. By the way, this unit also works out great for boosting the sensitivity of the Spectrum Analyzer by 10 dB! That gives you two applications for a single $15 investment!

2.) Add AM and/or FM modulation.

Since the generator is voltage-tuned, adding an AC component to the tuning voltage would Frequency Modulate the output of the generator. This AC component could be a sawtooth (for sweep alignment), or audio or video for other applications. Adding the AC component to the B+ supply of the 65 MHz oscillator could Amplitude Modulate the output.

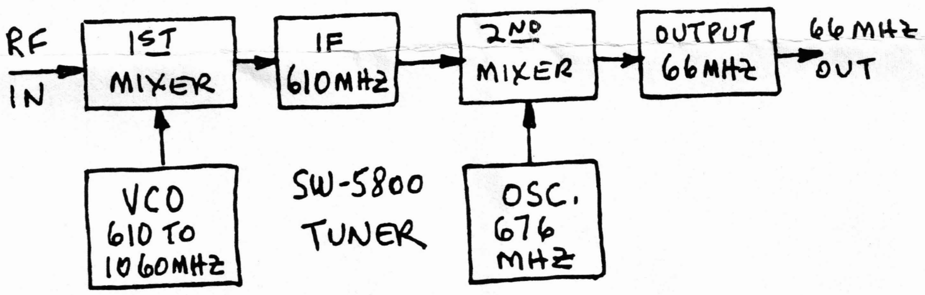
3.) Add an attenuator.

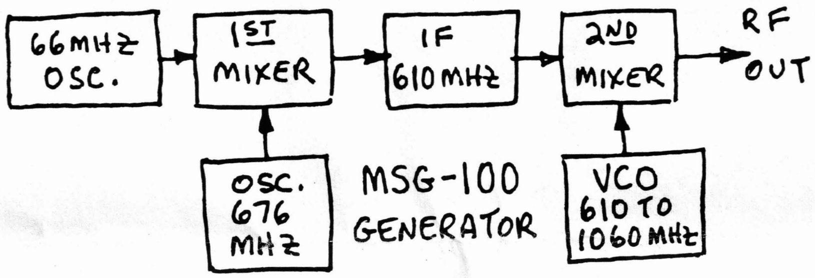
If additional gain is added to boost the output of the generator, a variable attenuator would be another useful addition. It could either be a step attenuator or a continuously variable one. Look for surplus units at most hamfests.

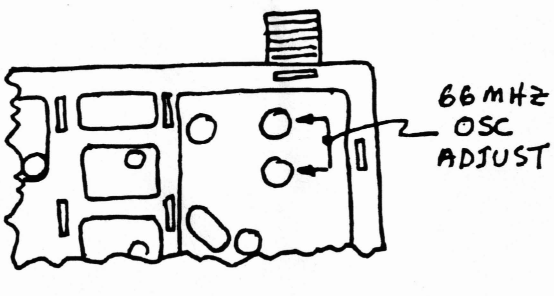
After the unit is completed, the output of the generator has to be coupled to the input of the Spectrum Analyzer. This can be done by adding either a resistor or capacitor between the output of the generator and the input of the analyzer. The value of the resistor or capacitor should be adjusted to provide a marker "pip" with just enough amplitude so that it can be easily recognized across the full range of the analyzer. The signal could also be coupled into the analyzer by adding a small whip antenna to the output of the analyzer, close enough so that it can be picked up by the analyzer. Varying the tuning voltage should cause the "pip" to move across the display. When the "pip" is superimposed on to the unknown signal, it's frequency can then be read directly from the digital display for the generator.

CALIBRATION

A comparison of the block diagrams of the SW-5800 tuner and the MSG-100 generator shows us how the modifications have made one the opposite of the other. The tuner accepts a wide range of input signal frequencies and converts them to 66 MHz, while the generator takes 66 MHz and converts it into a wide range of output frequencies. Since we start out with a 66 MHz oscillator and mix it up and down to produce the output frequency, it's actual frequency effects the generator's output frequency. Calibration of the generator is accomplished by adjusting either one of two inductors in the 66 MHz oscillator circuit. A small hex alignment tool can be used to adjust the cores which are accessible through the two holes indicated in the drawing. It is important to remember that the SW-6007 Digital Frequency Readout is actually displaying the frequency of the VCO, offset by the 610 MHz IF. This is an indirect display of the RF signal generated. It is correct only if the 66 MHz signal is correct. Tuning the 66 MHz oscillator does not change the VCO frequency display. It does affect the RF signal output frequency. When we calibrate the generator by tuning the 66 MHz oscillator, we are adjusting the RF output frequency to match the display, rather than the other way around,

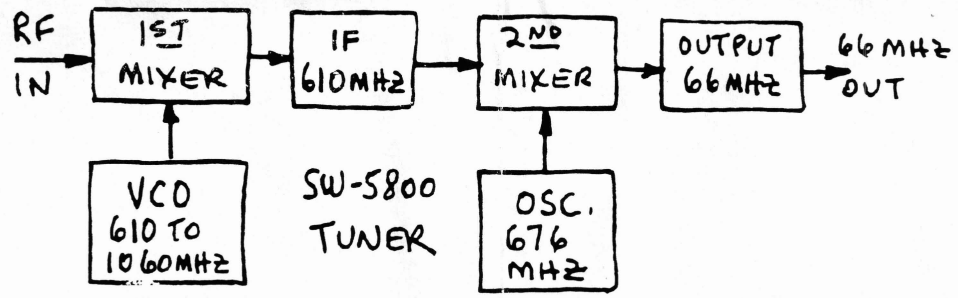






CONNECTING THE SW-5800 MODIFIED CABLE TUNER

This tuner has been modified to extend the lower end of it's frequency coverage from 50 Mhz to approximately 1 or 2 Mhz. In addition, it's 1st and 2nd IF bandwidths have been reduced to make it more useful in our application. Unfortunately, we have never been able to get a copy of it's schematic.



This tuner is a double conversion unit, with a voltage tuned 1st local oscillator and a Surface Acoustic Wave unit stabilizing the 2nd local oscillator. The conversion gain is approximately 4 dB. It contains a pre-scaler that samples the 1st local oscillator and divides it by 256. This output can be used by the SW-6007 Digital Readout Interface Board to provide a continuous display of the center frequency. The front of the tuner has 2 "F" connectors, labeled "IN" and "OUT". "IN" is "RF IN" and "OUT" is "IF OUT". "OUT" should be connected to "C" and "D" on the SW-6006 Main Board with a short length of 75 ohm co-ax. The rear pin marked "TV" for Tune Voltage, should be connected to "F" on the Ramp Board. The "B+" pin should be connected to the 24 volt power supply. A good ground connection should be made between the tuner frame and "E" on the Ramp Board.

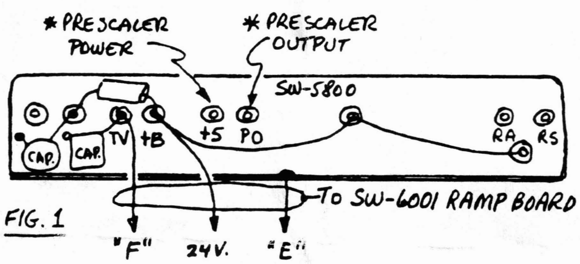
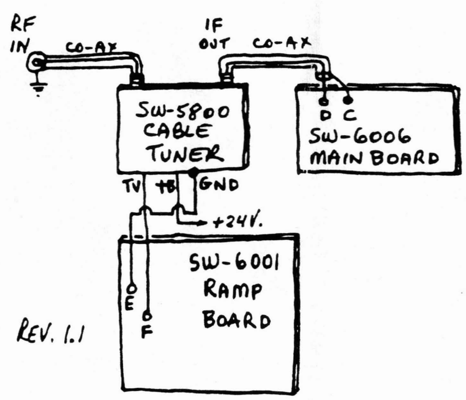


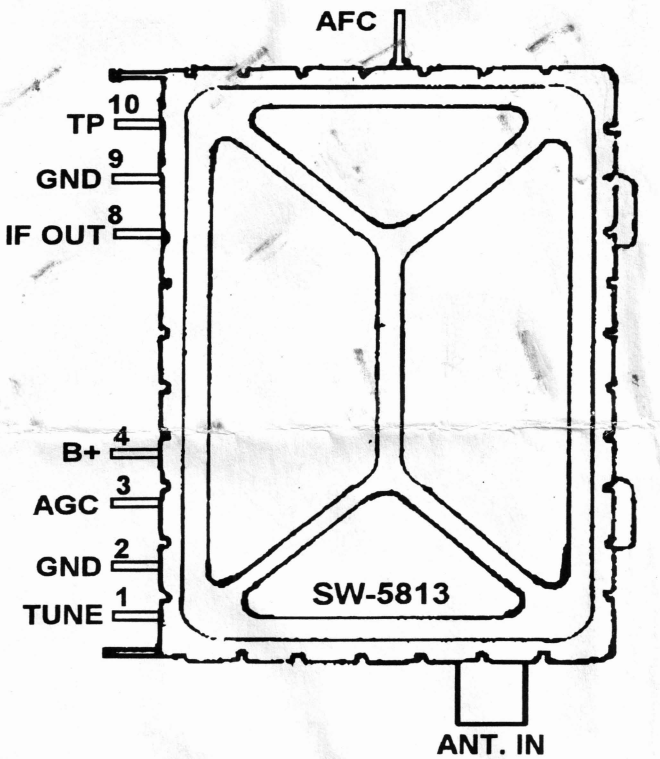
FIG. 1



REV. 1.1

ADDING THE SW-5813 UHF TUNER

Fig.1 Add a .01ufd DC blocking capacitor in series with the IF output lead.



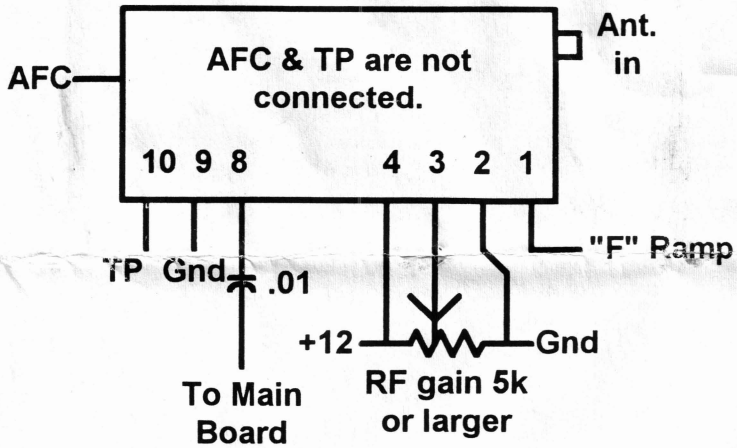


FIGURE 1

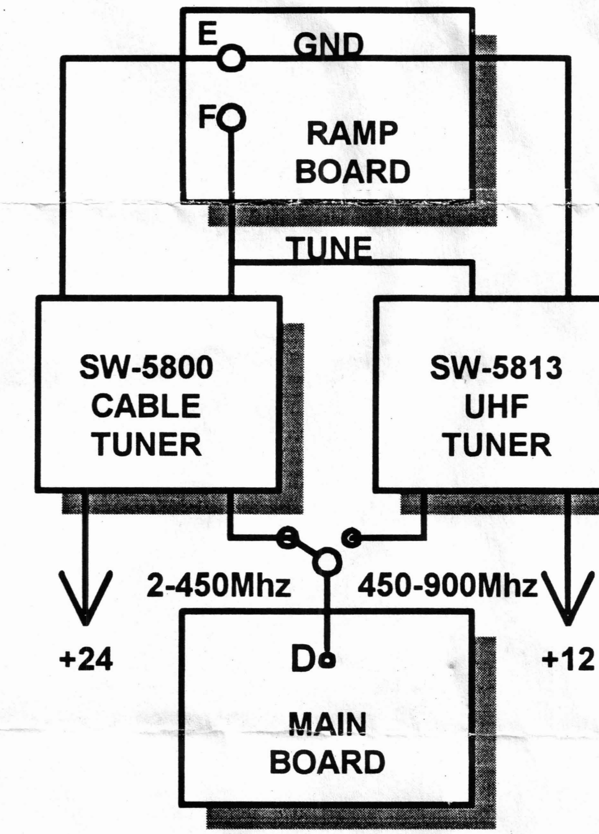
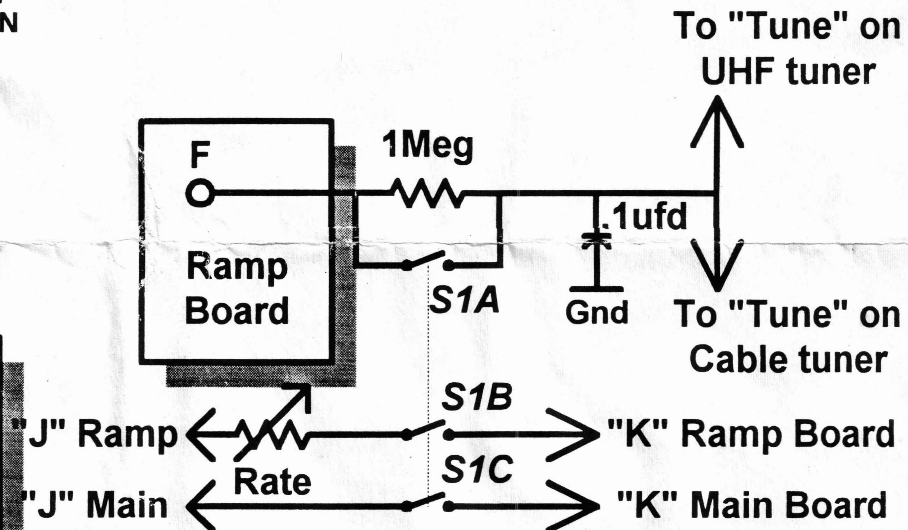


FIGURE 2

Fig. 2 illustrates how the SW-5813 can be added to provide UHF coverage. Co-ax, such as RG-174 can be used to connect the tuner IF outputs to the Main Board. B+ to the tuners should also be switched.



S1=Mode Switch, Up for Analyzer, Down for Receiver.

FIGURE 3

Fig. 3 This modification to improve audio reception in the "Receive" mode should be added between "F" on the Ramp Board and the "TUNE" inputs of both tuners, as illustrated. A 3 pole, 2 position "MODE"switch is used to switch between the ANALYZER and RECEIVER modes.

S1A adds the RC filter in RECEIVER mode.
S1B disables the ramp in RECEIVER mode.
S1C disables the audio in the ANALYZER mode.

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SCIENCE WORKSHOP
SW-6007 CENTER FREQUENCY READOUT CIRCUIT

This NEW KIT uses a unique combination of Analog and Digital circuitry to accomplish a relatively complex task. The conventional approach to this problem has always been purely digital, requiring anywhere from 10 to 20 digital chips. There had to be a simpler, more economical way, hopefully in line with the philosophy demonstrated by the design of the "Poor Man's Spectrum Analyzer". Since we are looking at a CRT display, covering anywhere from a few Mhz to several hundred MHz, what we need is a 3 digit readout that could display 0 to 500 MHz directly.

PREVIOUS SOLUTIONS.

Most frequency readout circuits use the local oscillator signal to generate the display. This signal is offset from the incoming RF signal by an amount equal to the IF frequency. A little arithmetic must be performed to either add or subtract the IF signal to get back to the received frequency. This has required the use of heterodyne oscillators, presettable counters, or the need to play games with the time base to accomplish the same result. These methods however, provide a relatively inflexible solution.

NEW APPROACH.

Rather than using the conventional all digital circuit, I decided to use a precision Frequency-to-Voltage converter IC, along with the output of the pre-scaler IC in the SW-5800 tuner. A bit of Analog Computer circuitry took care of the remaining math. Although this circuit was designed to work with the SW- 5900 tuner, it could provide experimenters with a simple low cost solution for directly displaying the received frequency of almost ANY receiver. A simple adjustment of a potentiometer is all that is required to accommodate any IF frequency offset from 0 to hundreds of MHz. For the first time, a TRULY UNIVERSAL DIRECT DIGITAL FREQUENCY READOUT!

HOW THE CIRCUIT WORKS.

The SW-5800 tuner has a first IF of 610 MHz. The first local oscillator uses high-side injection, which means that to tune from 0 to 500 MHz it must vary from 610 to 1110 MHz. This signal is divided by 256 by the pre-scaler in the tuner. The output of the pre-scaler varies from 2.38 to 4.33 MHz (610 to 1110 divided by 256). This is applied to the input of the Digital Readout Board. A two transistor preamp interfaces the input signal to a pair of divider chips that further divide the signal by 1,000. The resulting 2.38 to 4.33 KHz signal is applied to a precision frequency-to-voltage converter. From here on, the circuit is all Analog. The 2.38 KHz to 4.33 KHz signal is now a 2.33 to 4.33 VOLT signal. An op-amp provides Analog multiplication (X 2.56), and a DC OFFSET control adjustment performs an Analog subtraction, (-6.10) to compensate for the 610 MHz IF offset. The digital equivalent of this process would have required many more digital chips. The resultant output voltage varies from 0 to 5.00 volts.

DISPLAY OPTIONS.

To keep costs down, I designed the circuit so that it could use your Digital Voltmeter as the display. With the meter set on the 20 volt scale, 0 to 500 MHz would be displayed as 0.00 to 5.00 volts. At first I found the decimal point annoying, but it didn't take too long before I was ignoring it. Later, when I found time, I bought a $29 DVM, disabled the decimal point and dedicated that meter display to my Spectrum Analyzer. (We now have Miniature LCD Digital Panel Meter Modules available that are ideal for this application. They measure approximately 1" x 2" x 0.5" and easily mount into a rectangular cut out.)

OTHER APPLICATIONS FOR THE SW-6007.

There should be many other "frequency meter" type applications for this unique circuit. Since this circuit could be used with ANY I.F., it represents a real breakthrough. Adjusting the I.F. offset with the simple setting of a single control has been unheard of until now! All that is necessary is to feed the local oscillator signal into the input of the board, make sure that the output frequency of the dividers falls within the range (approximately 0.5 to 10 KHz) of the F/V converter, and then perform the calibration procedure. Changing some of the jumpers (note the extra hole above the jumper at Test Point #1) provides an extra measure of flexibility. The output of the dividers can be chosen so that the input is divided by any combination of the four "divide by 2" and "divide by 5" stages. The input and output of the individual divider stages could be brought out to a front panel switch to provide a wide range of frequencies that could be measured by this circuit. I would be most interested in hearing about any ideas that you might come up with.

PARTS LIST

RESISTORS		CAPACITORS	INDUCTORS
R1.......2.2K	R11.....15K	C1..........02mfd	L1......RF choke
R2.....1Meg	R12.....13K	C2..........02mfd	L2......RF choke
R3........750	R13...100K	C3..........02mfd	**TRANSISTORS**
R4........68K	R14.....68K	C4.........0.1mfd	Q1.......2N5459
R5........470	R15.....39K	C5...........470pf	Q2......2N3904
R6..........1K	R16......5K*	C6.......0.01mfd	**IC's**
R7........10K	R17....6.8K	C7.........0.1mfd	U1......74LS390
R8........10K	R18....10K*	C8.........1.0mfd	U2......74LS390
R9........68K	R19......5K*		U3........LM331
R10.....6.8K	* = trimpots		U4........LM324

ASSEMBLY INSTRUCTIONS

The following assembly procedure is recommended:

1.) Install 8 jumpers as indicated in figure 1. The jumpers labeled "1, 2, 3, & 4" will be used as test points for calibration and should be formed as "loops". See figure 2.

2.) Install 2 inductors, 16 resistors and 3 trimpots as in figure 3. Solder the grounded ends of the five resistors marked "X" on both sides of the PC board.

3.) Install 2 transistors and 8 capacitors, as in figure 4.

4.) If you haven't had much experience working with IC's, install sockets for the 4 chips. They have all been tested before being shipped. Handle them carefully! Install them in the locations indicated. Note the location of the number 1 pin.

5.) Check your work carefully for excess solder, splashes, shorts or "cold" solder joints. This completes the assembly.

SCIENCE WORKSHOP
SW-6007 CENTER FREQUENCY READOUT CIRCUIT

TEST AND CALIBRATION PROCEDURE.

NOTE: The accuracy and stability of the display is directly related to the accuracy and stability of the power supply voltage. Final calibration should not be performed until the power supply has warmed up and is stable. Since we are calibrating circuits working with small DC voltages, careful attention to accurate set up measurements will assure accurate results.

1) Connect a Digital Voltmeter between Test Point #3 and ground.

2) Connect regulated +18 volts between the + 18 volt terminal and ground. Neither the + 5 volt supply or the input signal need to be connected at this time.

3) Apply + 2.77 volts between Test Point #2 and ground.

4) Adjust the "Gain" trimpot (R18) for +7.09 volts between Test Point #3 and ground.

5) Shift the Digital Voltmeter negative test lead from ground to Test Point #4. Leave the positive test lead at Test Point #3.

6) Adjust the "Offset" trimpot (R19) for +1.00 volt on the Digital Voltmeter.

7) Now connect the output of the prescaler on the SW-5800 tuner to the input of the Digital Readout Board. Also connect the +5 volt regulated supply between the +5 volt terminal and ground.

8) If a signal generator is available, set it to 100 MHz and tune the Spectrum Analyzer so that the 100 MHz signal is centered on the CRT. Use a relatively small scan "width" setting on the Analyzer.

9) Adjust the "Calibration" trimpot (R16) for +1.00 volt (representing 100 MHZ). on the Digital Voltmeter. This completes the calibration process. If a signal generator is not available, any known signal can be used just as well.

TROUBLESHOOTING.

Your 'scope and Digital Voltmeter are all that are necessary to correct a problem, if the calibration procedure can not be performed. The first part of the calibration procedure uses the circuits of the op-amp, U4. Any problem here would be limited to this chip and it's components. Your Digital Voltmeter and our "Typical voltage and resistance chart" should locate the problem. The second part of the procedure depends upon the correct operation of the remainder of the circuit. It can be broken down into three parts, the preamp, the dividers and the F/V converter. Your 'scope can be used to check the operation of the preamp (Q1 and Q2) and the dividers (U1 and U2). Trace the 2.38 to 4.33 MHz signal from the tuner prescaler output to the board and thru the preamp. Remember, +5 volts must be supplied to the prescaler "+5" volt terminal on the SW-5800 tuner. The jumper between the output of the preamp and pin #4 of U1 is a convenient place to check for the output of the preamp. It should be approximately 3 volts peak to peak. No signal would indicate a problem in the preamp. The next test would be at Test Point #1. A square wave of almost 5 volts peak to peak would be present here. No signal would indicate a problem in the divider circuits. Finally, your Digital Voltmeter connected to Test Point #2 should show a DC voltage that will vary from 2.38 volts to 4.33 volts, depending upon the frequency tuned to by the SW-5800. Spurious signals may be generated by the circuits on this board. They can get into the tuner and show up on the CRT display. This can be checked by disconnecting the Input signal to the board.

SCIENCE WORKSHOP
SW-6007 CENTER FREQUENCY READOUT CIRCUIT

Using a double-sided board with maximum ground plane area, in conjunction with L1 and L2 should prevent this from happening. If it persists, check the grounding between the ground planes of the PC board and the chassis. It may be necessary to add additional capacitive filtering to the +5 and +18 volt leads at the board terminals. This means both hi-freq. (feed thru capacitors) as well as electrolytic capacitors. Otherwise, the power supply leads may radiate.

VOLTAGE AND RESISTANCE MEASUREMENTS.

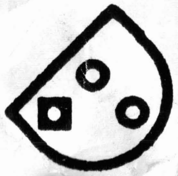
The following set of readings were taken with the Spectrum Analyzer tuned to 100 MHz. The values stated should not be taken as absolute, but are provided only as an aid for troubleshooting. Voltages on the unused IC pins can vary all over the lot, others can easily vary 20% or more. All readings are referenced to ground.

VOLTAGE READINGS (In DC volts, measured with a DVM).

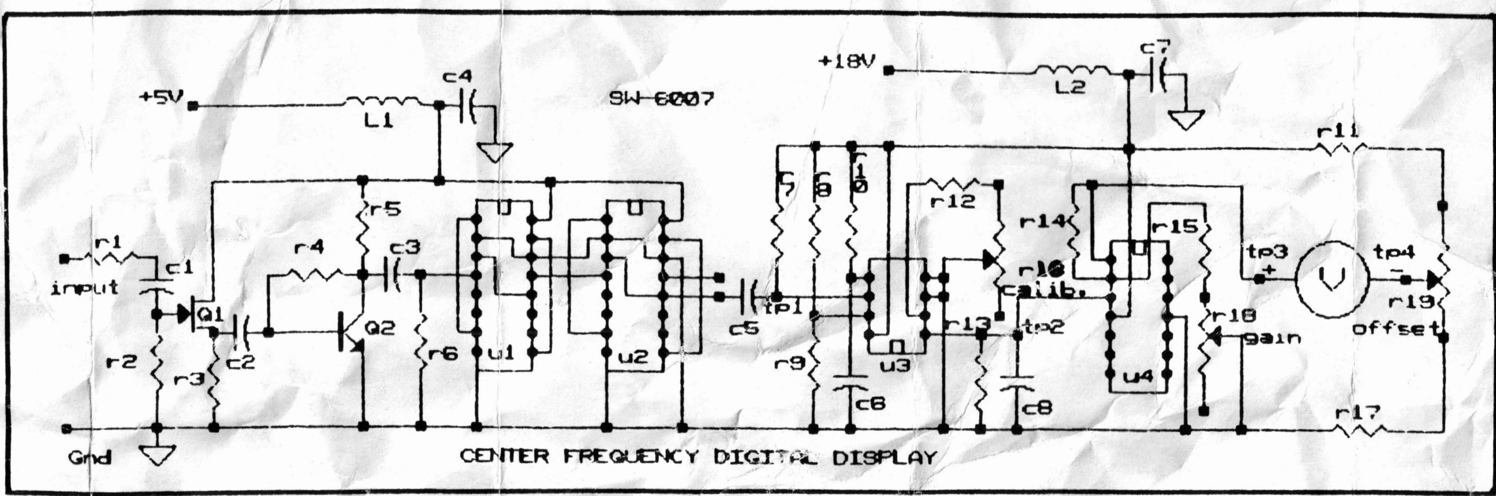
Q1	U1		U2		U3	U4	
Source...0.88	1...0.76	9.....0.87	1...0.90	9.....0.90	1.....2.70	1.....7.09	8....16.4
Gate.......0.00	2...0.00	10...1.50	2...0.00	10...1.60	2.....1.80	2.....2.70	9....2.14
Drain......4.57	3...1.90	11...1.50	3...2.00	11...1.60	3.....0.00	3.....0.00	10..2.50
	4...1.20	12...1.90	4...2.00	12...2.00	4.....0.00	4...17.70	11..0.00
Q2	5...1.30	13...2.00	5...1.60	13...2.00	5.....1.60	5.....2.10	12..2.30
Emitter...0.00	6...1.30	14...0.00	6...1.60	14...0.00	6...17.70	6.....2.00	13..2.30
Base......0.20	7...0.70	15...0.80	7...0.90	15...0.92	7...15.30	7...16.40	14..6.40
Coll........2.19	8...0.00	16...4.50	8...0.00	16...4.50	8...17.70		

RESISTANCE READINGS (in ohms).

Q1	U1		U2		U3	U4	
Source...1K	1.........*	9.........*	1.........*	9.........*	1..100K	1..111K	8.......*
Gate..1Meg	2.........0	10.......*	2.........0	10.......*	2.13.9K	2....44K	9.......*
Drain....750	3.........*	11.......*	3.........*	11.......*	3........0	3....98K	10.....*
	4......1K	12.......*	4.........*	12.......*	4........0	4....16K	11.....0
Q2	5.........*	13.......*	5.........*	13.......*	5....23K	5.......*	12.....*
Emitter.....0	6.........*	14.......0	6.........*	14.......0	6....26K	6.......*	13.....*
Base....70K	7.........*	15.......*	7.........*	15.......*	7....21K	7.......*	14.....*
Coll.....1.5K	8.........0	16....1K	8.........0	16....1K	8....16K		
*= Infinite							



* NoTe. Q1-The 2N5459 JFET replaces a part that is no longer available. Carefully align it's leads over the Q1 hole pattern. Insert the 3 leads as indicated and solder.



CENTER FREQUENCY DIGITAL DISPLAY

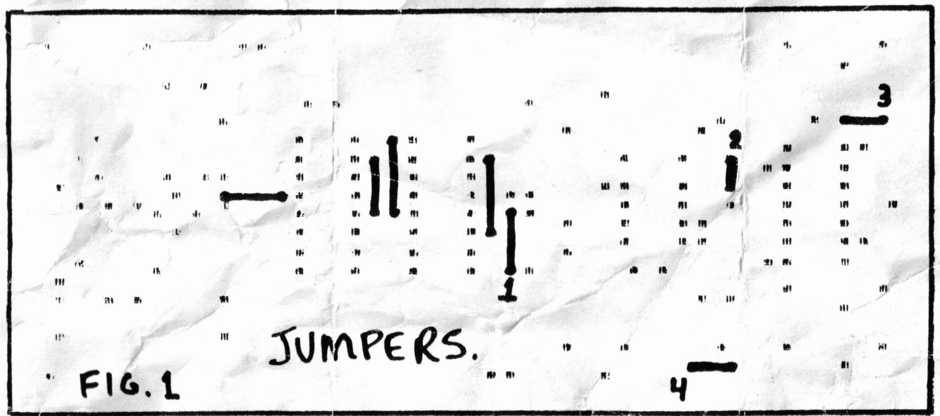
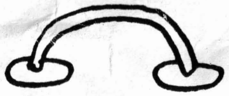


FIG. 1 JUMPERS.

FIG. 2



JUMPERS NUMBERED 1 THRU 4 SHOULD BE FORMED INTO "LOOPS" FOR TEST POINTS. NUMBERS 3 AND 4 ARE ALSO USED AS "OUTPUT" TERMINALS.

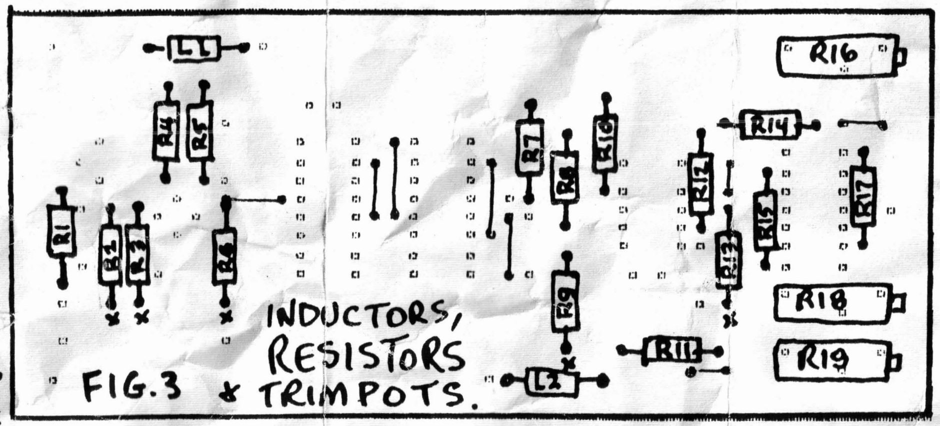


FIG. 3 INDUCTORS, RESISTORS & TRIMPOTS.

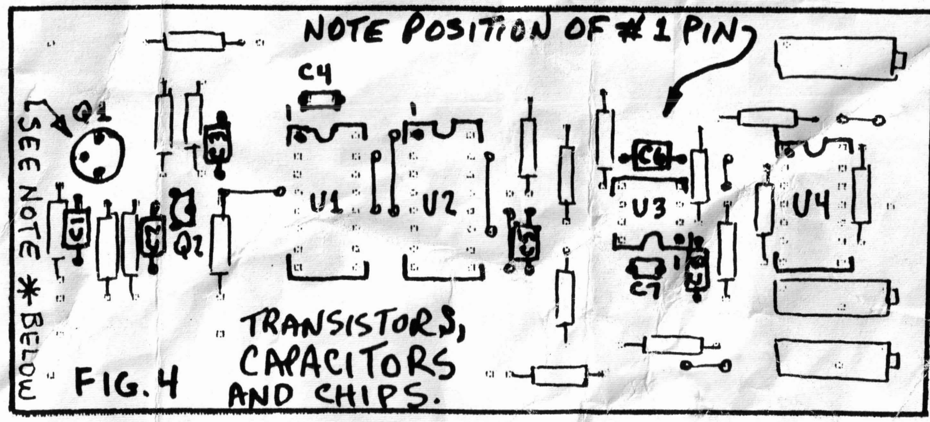


FIG. 4 TRANSISTORS, CAPACITORS AND CHIPS.

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